DAMES & MOORE

A DAMES & MOORE GROUP COMPANY

Evaluation of Air Toxics Health Risks – Final Report

Gregory Canyon Landfill

Prepared by:

Dames & Moore
9665 Chesapeake Drive, Suite 201
San Diego, California 92123
Project No. 38724-002-131

Prepared for:

David Evans & Associates
23382 Mill Creek Drive, Site 225
Laguna Hills, California 92653

January 7, 1999

APPENDIX K

EXCERPTS FROM EVALUATION OF AIR TOXICS HEALTH RISKS - FINAL REPORT (DAMES & MOORE, JANUARY, 1999)

DAMES & MOORE
A DAMES & MOORE GROUP COMPANY

Table of Contents

FIGURES

TABLES

ATTACHMENTS

pollutants. Landfill gas generation will initially be very small, but will increase throughout the period over which waste is accepted and decrease thereafter. The rise and fall of emissions from the flare will linearly track the gas generation rate. On the other hand, excavation activities, which will coincide with the maximum dust and equipment exhaust emissions from the project, will occur primarily during several periods relatively early in the lifetime of the landfill.

Since these different source categories will generate different sets of toxic air pollutant emissions at different times and in different locations within the project area, we have elected to evaluate the risks from all project sources for two separate emission scenarios. In the first scenario, we estimate health risks for Year 11 of the landfill's operational lifetime, when dust and equipment exhaust emissions are near their highest levels and landfill gas generation is at 45% of the maximum rate. The second scenario is for Year 29, when the generation of landfill gas will reach its maximum level and dust generation will be lower due to prior completion of earth excavation and stockpiling activities. No other years of landfill operation are expected to produce higher total emissions throughout the facility's lifetime.

Subsections 2.1 and 2.2 describe the methods and assumptions used to develop TAC emissions estimates for the landfill gas/flare sources and the fugitive dust/equipment exhaust sources, respectively. Section 2.3 presents the manner in which these source emissions were represented for input to the dispersion and risk modeling analyses.

2.1 Landfill Gas and Flare Emissions

The basic approach used to estimate landfill gas emission rates of TACs for the proposed Gregory Canyon Landfill follows the guidance in Section 2.4, Municipal Solid Waste Landfills, from EPA Document AP-42, *Compilation of Air Pollutant Emission Factors* (USEPA 1998a). This section of AP-42 has been revised twice during 1998.

The first step in estimating TAC emissions for the landfill and flare involves estimation of the uncontrolled landfill methane generation rate for each year of the facility's lifetime using the formula:

$$Q_{CH4} = L_o R\,(e^{-kc} - e^{-kt}) \qquad \text{(Equation 2-1)}$$

where:

Q_{CH4}	=	Methane generation rate at time t (m^3/year);
Lo	=	Methane generation rate potential (m3 CH4 per Mg refuse);
R	=	Average annual refuse acceptance rate during active life (Mg/year);
e	=	Base log (unitless);
k	=	Methane generation rate constant (year-1);
c	=	Time since landfill closure (years) (c = 0 for active landfills);
t	=	Time since the initial refuse placement (years).

Table 2-1 shows the parameter values used to calculate annual methane generation volumes for the first 70 years of the landfill's existence. The table indicates that maximum gas production will increase each year until the 29th year of operation and will decline steadily thereafter as waste receipts are discontinued. The highest predicted methane gas generation rate in Year 29 is 42.1 million cubic meters (10^6 m^3/yr), while the average rate over the full 70 years is 26.5 x 10^6 m^3/yr. The methane generation rate in the analysis year chosen to represent maximum dust and equipment exhaust emission conditions (Year 11) is 18.9 x 10^6 m^3/yr.

Equation 2-2 is used to estimate emissions of individual TACs contained within the landfill gas.

$$Q_P = 1.82\ Q_{CH4} \times C_P/(1.0 \times 10^6) \qquad \text{(Equation 2-2)}$$

where:

Q_P	=	Emission rate of pollutant P (m^3/yr);
QCH4	=	Methane generation rate (m3/year);
CP	=	Concentration of P in the landfill gas (ppmv);
1.82	=	Multiplication factor to convert from methane to total landfill gas volume (assumes approximately 55% of landfill gas is methane and 45% is CO2, N2 and other constituents).

The EPA AP-42 document provides lists of toxic compounds that may be found in landfill gas and default concentrations for the individual constituents. These compounds and the corresponding default landfill gas concentrations specified in AP-42 are shown in Table 2-2.

The AP-42 document encourages the use of site-specific data over the default information when available. For this health risk assessment, most of the default concentrations were assumed to be applicable to the gas emissions that will be generated by the Gregory Canyon landfill. However, in the case of acrylonitrile, an exception was made, because all available evidence points to an expectation of much lower levels of this compound than indicated by the AP-42 default value. This evidence includes the following:

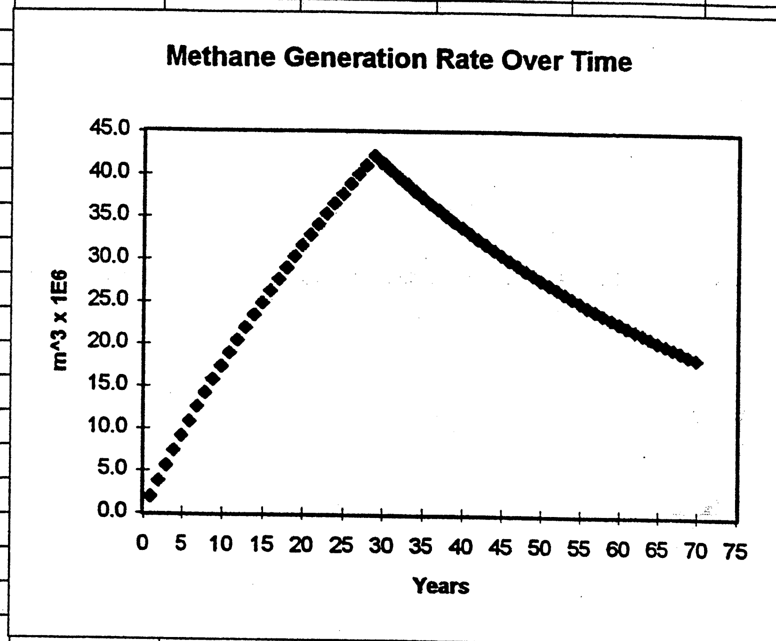
- Discussions with EPA staff responsible for the development of the relevant AP-42 section
- Discussions with staff of the South Coast Air Quality Management District who oversee that agency's landfill gas sampling program and a laboratory with extensive landfill gas speciation experience; and
- Samples collected on behalf of the proposed Gregory Canyon project at two operating Southern California municipal landfills.

Table 2-1
Uncontrolled Methane Generation Rate Calculation for Gregory Canyon Landfill (1 of 2)

QCH4=Lo * R * (e^-kc - e^-kt)

Lo (m^3/Mg) =	100	(100 from AP-42 for most landfills)
k (1/yr) =	0.02	(0.02 from AP-42 for drier areas, less than 25 inches of rain per year)
R (Mg/yr) =	9.57E+05	

c (yrs)	t (yrs)	QCH4 (1E6 m^3/yr)
0	1	1.9
0	2	3.8
0	3	5.6
0	4	7.4
0	5	9.1
0	6	10.8
0	7	12.5
0	8	14.2
0	9	15.8
0	10	17.4
0	11	18.9
0	12	20.4
0	13	21.9
0	14	23.4
0	15	24.8
0	16	26.2
0	17	27.6
0	18	28.9
0	19	30.3
0	20	31.6
0	21	32.8
0	22	34.1
0	23	35.3
0	24	36.5
0	25	37.7
0	26	38.8
0	27	39.9
0	28	41.0
0	29	42.1
1	30	41.3
2	31	40.5
3	32	39.7
4	33	38.9
5	34	38.1
6	35	37.4
7	36	36.6
8	37	35.9
9	38	35.2
10	39	34.5
11	40	33.8
12	41	33.1



QCH4: Methane generation rate at time t, m^3/yr
Lo: Methane generation potential, m^3 CH4/Mg refuse
R: Average annual refuse acceptance rate during active life, Mg/yr
e: Base log, unitless
k: Methane generation rate constant, 1/yr
c: Time since landfill closure, yrs (c=0 for active landfills
t: Time since the initial refuse placement, years

Assumed:
Landfill collects 30.6E6 tons of refuse
Landfill collects refuse for 29 years
Landfill gas (steady state) 40% vol CO2, 55% vol CH4, 5% vol N2

Ave QCH4 (1E6 m^3/yr) = 26.5

Table 2-1
Uncontrolled Methane Generation Rate Calculation for Gregory Canyon Landfill (2 of 2)

13	42	32.5							
14	43	31.8							
15	44	31.2							
16	45	30.6							
17	46	30.0							
18	47	29.4							
19	48	28.8							
20	49	28.2							
21	50	27.7							
22	51	27.1							
23	52	26.6							
24	53	26.1							
25	54	25.6							
26	55	25.0							
27	56	24.6							
28	57	24.1							
29	58	23.6							
30	59	23.1							
31	60	22.7							
32	61	22.2							
33	62	21.8							
34	63	21.3							
35	64	20.9							
36	65	20.5							
37	66	20.1							
38	67	19.7							
39	68	19.3							
40	69	18.9							
41	70	18.6							

Table 2-2
AP-42 List of Toxic Compounds in Landfill Gas

Pollutant	Molecular Weight	Default Landfill Gas Concentrations	Pollutant	Molecular Weight	Default Landfill Gas Concentrations
1,1,1-Trichloroethane	133.41	0.48	Dichlorofluoromethane	102.92	2.62
Tetrachloroethane	167.85	1.11	Methylene chloride	84.94	14.3
1,1-dichloroethane	98.97	2.35	Dimethyl sulfide	62.13	7.82
1,1-dichloroethene	96.94	0.2	Ethane	30.07	889
1,2-dichloroethane	98.96	0.41	Ethanol	46.08	27.2
1,2-dichloropropane	112.99	0.18	Ethyl mercaptan	62.13	2.28
2-Propanol	60.11	50.1	Ethylbenzene	106.16	4.61
Acetone	58.08	7.01	Ethylene dibromide	187.88	0.001
Acrylonitrile	53.06	6.33	Fluorotrichloromethane	137.38	0.76
Benzene	78.11	1.91	Hexane	86.18	6.57
Bromodichloromethane	163.83	3.13	Hydrogen sulfide	34.08	35.5
Butane	58.12	5.03	Mercury	200.61	0.000292
Carbon disulfide	76.13	0.58	MEK	72.11	7.09
Carbon Monoxide	28.01	141	MIBK	100.16	1.87
Carbon tetrachloride	153.84	0.004	Methyl mercaptan	48.11	2.49
Carbonyl sulfide	60.07	0.49	Pentane	72.15	3.29
Chlorobenzene	112.56	0.25	Tetrachloroethylene	165.83	3.73
Chlorodifluoromethane	86.47	1.3	Propane	44.09	11.1
Chloroethane	64.52	1.25	t-1,2-dichloroethene	96.94	2.84
Chloroform	119.39	0.03	Toluene	92.13	39.3
Chloromethane	50.49	1.21	Trichloroethylene	131.4	2.82
Dichlorobenzene (p-: HA	147	0.21	Vinyl chloride	62.5	7.34
Dichlorodifluoromethane	120.91	15.7	Xylenes	106.16	12.1
			NMOC (AP-42 8/98)	86.18	595

Because of the high cancer unit risk value assigned to acrylonitrile by the State Office of Environmental Health Hazard Assessment (OEHHA), this compound would dominate the calculation of cancer risk for the landfill project if the default acrylonitrile concentration value in AP-42 were used. Research into the basis for the EPA factor shows that this value was actually derived from only four samples collected in different U.S landfills. (USEPA, 1998b). The range of these four values was 0.81 to 28.3 ppmv, with the geometric mean value of 6.33 used as the default value. The documentation for this supporting data states that the high value of 28.3 ppmv, which is higher than the other three individual samples by a factor of from 3 to 35, was obtained at a landfill in the Eastern US.

Staff of the SDAPCD who were contacted regarding the history of landfill gas sampling and speciation for waste disposal facilities in San Diego stated that they are unaware of any analysis having been conducted for acrylonitrile at local landfills. A more comprehensive program of routine landfill gas sampling and analysis is conducted in the South Coast Air Quality Management District (SCAQMD) pursuant to that agency's Rule 1150.1. Accordingly, SCAQMD staff were also contacted regarding acrylonitrile emissions from Southern California landfills.

Mr. Ron Meyers of EPA, who participated in the preparation of Section 2.4 of AP-42, stated that most of the TACs for landfill gas (including acrylonitrile) have been placed in landfills as components of the waste from specific industrial processes, and are not produced in the landfill by the biodegradation process that generates methane (Meyers, 1998). He also said that the presence or absence of some of these compounds sometimes depends on the age of the landfill, since the types of wastes accepted by municipal solid waste facilities have become much more restricted over the last several years. Thus compounds that have been found in the gases of older landfills may not be present in newer facilities. Mr. Meyers also pointed out that sometimes sampling programs that detect high values of a compound like acrylonitrile have been conducted expressly because of an expectation that the compound is present due to the nature of the facility waste stream. According to the 1985 Kirk-Ohmer Encyclopedia of Chemicals, acrylonitrile is used primarily in the production of acrylic fibers, copolymer resins, adiponitrile and barrier resins.

Mr. Rod Millican and Mr. Joe Tramma are engineers with AQMD specializing in landfill permit issues. In a series of telephone conversations with Dames & Moore staff working on this health risk assessment, Mr. Millican related that the AQMD's in-house laboratory has never detected acrylonitrile in the relatively few instances when they have analyzed landfill gas for this compound. Acrylonitrile is one of the second-tier compounds listed in AQMD Rule 1150.1, for which sampling may be required if the District has reason to believe they will be found in appreciable quantities (Millican, 1998). Mr. Tramma told Dames & Moore that to his knowledge they have never had reason to require sampling for any of the compounds on the second-tier list (Tramma, 1998). On the recommendation of Mr. Millican, Dames & Moore also contacted Mr. Mike Porter, a

Principal of AtmAA, Inc a laboratory with extensive experience in the chemical analysis of landfill gas for toxic compounds. Mr. Porter confirmed that he has virtually never tested for acrylonitrile, but has occasionally seen its signature on the gas chromatograph trace in ppb levels when analyzing for other compounds, including acetylnitrile (Porter, 1998).

Because of the importance of the acrylonitrile concentration in determining the cancer risk associated with the Gregory Canyon landfill, a series of samples at the gas collection systems of two active landfills in the South Coast AQMD were collected by specialists of Bryan A. Stirrat & Associates (BAS) on December 15, 1998. These samples were specifically analyzed for acrylonitrile and vinyl chloride, another compound with a relatively high unit risk factor, to obtain an idea of the levels found in Southern California landfills. The concentrations of the two target compounds found in the two samples collected in the gas of both landfills were:

	Acrylonitrile	Vinyl Chloride
Landfill 1	< 3 ppbv, < 3 ppbv	137 ppbv, 131 ppbv
Landfill 2	< 3 ppbv, < 3 ppbv	331 ppbv, 394 ppbv
AP-42 Default	6.33 ppmv	7.34 ppmv

Clearly, these measured values, which were obtained in the gas collection system for landfills deliberately chosen for their similarity to the proposed Gregory Canyon facility, are far below the default concentrations specified in AP-42. Descriptions of the sampling and analysis methods utilized for the development of the landfill data are provided in Attachment 1.

Table 2-3 shows the TAC constituent concentrations assumed for the Gregory Canyon landfill gas. For acrylonitrile we have used the detection level of 3 ppbv as a conservative precaution, although the actual concentration is known to be below this threshold value. For vinyl chloride, the highest concentration measured by BAS, 394 ppbv, was assumed. These raw concentrations have been corrected in the table to account for air intrusion into the gas collection systems, as specified in AP-42. Based on the information provided by all the knowledgeable individuals who have been contacted, these acrylonitrile and vinyl chloride measurements are more indicative of the concentrations that will occur in the Gregory Canyon landfill gas than the EPA default values. The EPA values have been used for all other landfill gas constituents, however.

Table 2-3

List of Landfill Gas Toxic Compound Concentrations Used in the Gregory Canyon Health Risk Assessment

Pollutant	Molecular Weight	Assumed Landfill Gas Concentrations (ppmv)	Pollutant	Molecular Weight	Assumed Landfill Gas Concentrations (ppmv)
1,1,1-Trichloroethane	133.41	0.48	Dichlorofluoromethane	102.92	2.62
Tetrachloroethane	167.85	1.11	Methylene chloride	84.94	14.3
1,1-dichloroethane	98.97	2.35	Dimethyl sulfide	62.13	7.82
1,1-dichloroethene	96.94	0.2	Ethane	30.07	889
1,2-dichloroethane	98.96	0.41	Ethanol	46.08	27.2
1,2-dichloropropane	112.99	0.18	Ethyl mercaptan	62.13	2.28
2-Propanol	60.11	50.1	Ethylbenzene	106.16	4.61
Acetone	58.08	7.01	Ethylene dibromide	187.88	0.001
Acrylonitrile	53.06	0.003103	Fluorotrichloromethane	137.38	0.76
Benzene	78.11	1.91	Hexane	86.18	6.57
Bromodichloromethane	163.83	3.13	Hydrogen sulfide	34.08	35.5
Butane	58.12	5.03	Mercury	200.61	0.000292
Carbon disulfide	76.13	0.58	MEK	72.11	7.09
Carbon Monoxide	28.01	141	MIBK	100.16	1.87
Carbon tetrachloride	153.84	0.004	Methyl mercaptan	48.11	2.49
Carbonyl sulfide	60.07	0.49	Pentane	72.15	3.29
Chlorobenzene	112.56	0.25	Tetrachloroethylene	165.83	3.73
Chlorodifluoromethane	86.47	1.3	Propane	44.09	11.1
Chloroethane	64.52	1.25	t-1,2-dichloroethene	96.94	2.84
Chloroform	119.39	0.03	Toluene	92.13	39.3
Chloromethane	50.49	1.21	Trichloroethylene	131.4	2.82
Dichlorobenzene (p-: HA	147	0.21	Vinyl chloride	62.5	0.2552
Dichlorodifluoromethane	120.91	15.7	Xylenes	106.16	12.1
			NMOC (AP-42 8/98)	86.18	595

For purposes of the emissions calculations used in this assessment of health risks, it is assumed that all of the gas generated by the landfill is either collected by the gas collection system or finds its way to the atmosphere through cracks or other openings in the landfill surface. Based on information provided by the landfill design engineers, a gas collection efficiency of 90% has been assumed. This level of collection efficiency is feasible for a landfill design that utilizes a cup-shaped configuration and a sufficiently dense network of gas collection wells. A confirming statement on the validity of the 90% collection efficiency has been provided by BAS, the project design engineering firm, and is included as Attachment 2 to this report.

It is thus assumed that 10 percent of the generation rates for total landfill gas and of the individual toxic constituents therein will be emitted directly from the landfill surface. The remaining gas will be sent to the flare, where the assumed destruction efficiencies for this gas stream are 99.2% for non-methane organic compounds and 98% for halogenated organics (EPA AP-42). Calculated toxic air contaminant emissions for landfill gas and flare emissions in both selected modeling years are shown in Table 2-4.

As noted previously, annual average and maximum hourly emissions were used for the risk modeling conducted for this study. In response to instructions from staff of the APCD regarding interpretation of District Rule 1200, maximum annual emissions were used for the chronic health effects calculations. Specifically, the calculated average emission rates calculated by means of Equation 2-2 for Year 29 of the proposed facility's operation were used to represent maximum annual TAC emissions associated with landfill gas generation. Maximum hourly landfill gas emissions were assumed to be well approximated by the same emission rates, since there is no basis for determining short-term variations in landfill gas generation. Annual and maximum hourly TAC emissions data for landfill gas were similarly generated for the Year 11 model simulation by scaling the Year 29 rates by the ratio of methane gas generation for the two years.

2.2 Dust and Equipment Exhaust Emissions

Sources of fugitive dust associated with the operational Gregory Canyon landfill will include the following:

- Travel of waste hauling trucks and smaller vehicles to and from the landfill on paved roads and on unpaved areas within the landfill to and from waste offloading areas;
- Excavation of soil to create the landfill volume for waste placement and construction of the associated clay liner;
- Hauling and dumping of excavated soil in stockpiles;
- Operation of landfill equipment to spread, compact and cover received wastes.
- Periodic drilling, blasting and rock crushing;
- Windblown dust from stockpiles and exposed surfaces.

Table 2-4
Calculated Toxic Air Pollutant Emission Rates for Gregory Canyon Landfill Gas and Flare

Pollutant	Landfill Operational Year 29				Landfill Operational Year 11			
	Landfill Gas		Flare		Landfill Gas		Flare	
	Annual (lb/yr)	Max Hrly (lb/hr)	Annual (lb/yr)	Max Hrly (lb/hr)	Annual (lb/yr)	Max Hrly (lb/hr)	Annual (lb/yr)	Max Hrly (lb/hr)
1,1,1-Trichloroethane	4.427E+01	5.05E-03	7.969E+00	9.097E-04	1.988E+01	2.269E-03	3.578E+00	4.084E-04
1,1-dichloroethene	1.34E+01	1.53E-03	2.413E+00	2.754E-04	6.018E+00	6.869E-04	1.083E+00	1.236E-04
1,2-dichloroethane	2.81E+01	3.20E-03	5.049E+00	5.764E-04	1.259E+01	1.438E-03	2.267E+00	2.588E-04
Acrylonitrile	1.14E-01	1.30E-05	8.196E-03	9.356E-07	5.110E-02	5.833E-06	3.679E-03	4.200E-07
Benzene	1.03E+02	1.18E-02	7.426E+00	8.478E-04	4.630E+01	5.286E-03	3.334E+00	3.806E-04
Carbon tetrachloride	4.25E-01	4.86E-05	7.658E-02	8.742E-06	1.910E-01	2.180E-05	3.438E-02	3.924E-06
Chlorobenzene	1.95E+01	2.22E-03	3.502E+00	3.998E-04	8.734E+00	9.970E-04	1.572E+00	1.795E-04
Chlorodifluoromethane	7.77E+01	8.87E-03	1.399E+01	1.597E-03	3.489E+01	3.983E-03	6.280E+00	7.169E-04
Chloroethane	5.58E+01	6.37E-03	1.004E+01	1.146E-03	2.503E+01	2.857E-03	4.506E+00	5.143E-04
Chloroform	2.48E+00	2.83E-04	4.457E-01	5.088E-05	1.112E+00	1.269E-04	2.001E-01	2.284E-05
Dichlorobenzene (p-: HAP)	2.13E+01	2.44E-03	3.842E+00	4.385E-04	9.581E+00	1.094E-03	1.725E+00	1.969E-04
Dichlorodifluoromethane	1.31E+03	1.50E-01	2.362E+02	2.697E-02	5.892E+02	6.726E-02	1.061E+02	1.211E-02
Dichlorofluoromethane	1.86E+02	2.13E-02	3.356E+01	3.831E-03	8.369E+01	9.554E-03	1.506E+01	1.720E-03
Methylene chloride	8.40E+02	9.59E-02	1.512E+02	1.726E-02	3.770E+02	4.304E-02	6.786E+01	7.746E-03
Ethylene dibromide	1.30E-01	1.48E-05	9.352E-03	1.068E-06	5.831E-02	6.657E-06	4.199E-03	4.793E-07
Fluorotrichloromethane	7.22E+01	8.24E-03	1.299E+01	1.483E-03	3.241E+01	3.699E-03	5.833E+00	6.659E-04
Hydrogen sulfide	8.36E+02	9.55E-02	6.022E+01	6.875E-03	3.755E+02	4.287E-02	2.704E+01	3.086E-03
Mercury	4.05E-02	4.62E-06	3.645E-01	4.161E-05	1.818E-02	2.075E-06	1.636E-01	1.868E-05
Tetrachloroethylene	4.28E+02	4.88E-02	7.697E+01	8.787E-03	1.920E+02	2.192E-02	3.456E+01	3.945E-03
Toluene	2.50E+03	2.86E-01	1.802E+02	2.057E-02	1.124E+03	1.283E-01	8.091E+01	9.236E-03
Trichloroethylene	2.56E+02	2.92E-02	4.611E+01	5.264E-03	1.150E+02	1.313E-02	2.070E+01	2.363E-03
Vinyl chloride	1.10E+01	1.26E-03	1.985E+00	2.266E-04	4.950E+00	5.651E-04	8.911E-01	1.017E-04
Xylenes	8.88E+02	1.01E-01	6.394E+01	7.299E-03	3.987E+02	4.551E-02	2.871E+01	3.277E-03
Hydrogen Chloride	N/A	N/A	2.823E+04	3.222E+00	N/A	N/A	1.267E+04	1.447E+00